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(54) Polishing pad for a semiconductor wafer which has light transmitting properties

(57) An objective of the present invention is to provide a polishing pad (1) for a semiconductor wafer (12) and a laminated body for polishing of a semiconductor wafer (12) equipped with the same which can perform optical endpoint detection without lowering the polishing performance as well as methods for polishing of a semiconductor wafer (12) using them. The polishing pad (1) of the invention comprises a water-insoluble matrix material such as crosslinked 1,2-polybutadiene, and a water-soluble particle such as β-cyclodextrin dispersed in this water-insoluble matrix material, and has a light transmitting properties so that a polishing endpoint can be detected with a light.

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matrix material and a water-soluble particle dispersed in the above-mentioned water-insoluble matrix material.

5. The polishing pad for a semiconductor according to 4 above, wherein a light transmittance of the above-mentioned light transmitting part at a wavelength between 400 and 800nm is 0.1% or more, or an integrated transmittance of the above-mentioned light transmitting part in a wavelength range between 400 and 800nm is 0.1% or more, when a thickness is 2mm.

6. The polishing pad for a semiconductor according to any one of 1 to 5 above, wherein at least a part of the water-insoluble matrix material is a crosslinked polymer.

7. The polishing pad for a semiconductor according to 6 above, wherein the above-mentioned crosslinked polymer is crosslinked 1,2-polybutadiene.

8. The polishing pad for a semiconductor according to any one of 1 to 7 above, which is used in a semiconductor wafer polishing apparatus equipped with an optical endpoint detector.

9. A laminated body for polishing of a semiconductor wafer, which comprises a polishing pad for a semiconductor as defined in any one of 1 to 8 above and a supporting layer laminated on a backside of the above-mentioned polishing pad, wherein the above-mentioned laminate has transmitting properties in a laminated direction.

10. A method for polishing of a semiconductor wafer comprising a process of polishing a semiconductor wafer using a polishing pad for a semiconductor wafer as defined in any one of 1 to 8 above or a laminated body as defined in 9 above and a process of performing detection of a polishing endpoint using an optical endpoint detector.

Effects of the Invention

[0009] According to the polishing pad for a semiconductor wafer of the first and second aspects of the invention and the laminated body for polishing of a semiconductor wafer equipped with the same, optical detection of a polishing endpoint can be easily performed without lowering the polishing performance in polishing. In particular, according to the polishing pad of the first aspect of the invention, not only a polishing endpoint but also the all polishing situations can be always observed optically during polishing.

[0010] According to the method for polishing of a semiconductor wafer of the invention, the semiconductor wafer can be effectively polished while observing the polishing situation, and the semiconductor wafer is not polished excessively.

Detailed description of the Invention

[0011] The polishing pad for a semiconductor wafer (hereinafter also referred to as "polishing pad") of the first aspect of the invention is characterized in that it is comprised of a water-insoluble matrix material and a water-soluble particle dispersed in the above-mentioned water-insoluble matrix material, and has light transmitting properties.

[0012] The "water-insoluble matrix material" constituting the polishing pad for a semiconductor wafer according to the first aspect of the invention has a role in maintaining a shape of the polishing pad and retaining water-soluble particles in the polishing pad.

[0013] Materials forming the water-insoluble matrix material are not particularly limited as long as they can give light transmitting properties to the polishing pad, but include thermoplastic resin, thermosetting resin, elastomer, rubber and the like. These may be used alone or in combination of two or more.

[0014] Examples of the thermoplastic resin include polyolefin-based resin, polystyrene-based resin, polyacrylic-based resin such as (meth)acrylate-based resin, vinyl ester resin except for polyacrylic-based resin, polyester-based resin, polyamide-based resin, fluorine resin, polycarbonate resin, polyacetal resin and the like. These may be used alone or in combination of two or more.

[0015] Examples of the thermosetting resin include phenol resin, epoxy resin, unsaturated polyester resin, polyurethane resin, polyurethane urea resin, urea resin, silicone resin and the like. These may be used alone or in combination of two or more.

[0016] Examples of the elastomer include thermoplastic elastomers, silicone resin-based elastomer, fluorine resin-based elastomer and the like. The thermoplastic elastomers may be used styrene-based elastomer such as styrene-butadiene-styrene block copolymer (SBS), hydrogenated block copolymer thereof (SEBS), polyolefin elastomer (TPO), thermoplastic polyurethane elastomer (TPU), thermoplastic polyester elastomer (TPEE), polyamide elastomer (TPAE), diene-based elastomers such as 1,2-polybutadiene, and the like. These may be used alone or in combination of two or more.

[0017] Examples of the rubber include butadiene rubber, styrene-butadiene rubber, isoprene rubber, isobutylene-isoprene rubber, acrylic rubber, acrylonitrile-butadiene rubber, ethylene-propylene rubber, ethylene-propylene-diene rubber, silicone rubber, fluorine rubber and the like. These may be used alone or in combination of two or more.

[0018] These materials may be modified with an acid anhydride group, a carboxyl group, a hydroxyl group, an epoxy group, an amino group or the like. Modification can adjust the affinity and the like with a water-soluble particle, an abrasive, an aqueous medium and the like. In addition, these modified materials can be also used

preferable that respective water-soluble particles are similar in a shape. This makes shapes of formed pores uniform and, thus, better polishing can be performed.

[0029] In addition, a size of the above-mentioned water-soluble particle is not particularly limited but is, usually, 0.1 to 500μm, more preferably 0.5 to 100μm, most preferably 1 to 80μm. When the particle size is less than 0.1μm, a size of a pore is smaller than that of an abrasive in some times and an abrasive is not sufficiently retained in a pore in some times, being not preferable. On the other hand, when the particle size exceeds 500μm, the size of a formed pore becomes too large, and there is a tendency that the mechanical strength of the polishing pad and the removal rate are lowered.

[0030] An amount of the above-mentioned water-soluble particle contained in a polishing pad is preferably 10 to 90% by volume, more preferably 15 to 60% by volume, further preferably 20 to 40% by volume based on 100% by volume of the total amount of the water-insoluble matrix material and the water-soluble particle. When the content of the water-soluble particle is less than 10% by volume, a sufficient amount of pores are not formed, and a removal rate tends to be lowered. On the other hand, when the content exceeds 90% by volume, there is a tendency that not only water-soluble particles exposed on the surface of a polishing pad but also water-soluble particles existing in the interior thereof can be prevented from dissolving or swelling with difficulty. Therefore, it becomes difficult to retain the hardness and the mechanical strength of a polishing pad at an appropriate value during polishing.

[0031] In addition, it is preferable that only water-soluble particles exposed on the surface of a polishing pad are dissolved in water, and water-soluble particles existing in the interior of the polishing pad without emerging on the surface do not absorb moisture and are not swollen. For this reason, an outer shell composed of epoxy resin, polyimide, polyamide, polysilicate and the like for inhibiting moisture absorption may be formed on at least a part of an outermost part of the water-soluble particle.

[0032] The above-mentioned water-soluble particle has the function of increasing an indentation hardness of a polishing pad, in addition to the function of forming a pore during polishing. For example, a preferable Shore D hardness is 35 to 100. This large indentation hardness can increase a pressure loaded on the surface to be polished by using a polishing pad and can enhance a removal rate and, at the same time, the high flatness can be obtained. Therefore, it is preferable that this water-soluble particle is a solid particle which can retain a sufficient indentation hardness in a polishing pad.

[0033] A method of dispersing the above-mentioned water-soluble particle in the water-insoluble matrix material is not particularly limited. Usually, a material constituting the above-mentioned water-insoluble matrix material, a water-soluble particle and other additives are kneaded. In this kneading, a material constituting the water-insoluble matrix material is kneaded while heating so as to be easily processed. It is preferable that the water-soluble particle is solid at kneading temperature. When the particle is solid, the water-soluble particle is easily dispersed in the state where the above-mentioned preferable average particle size is retained, regardless of a magnitude of the compatibility with the above-mentioned material constituting the water-insoluble matrix material. Therefore, it is preferable that a kind of water-soluble particle is selected depending upon a processing temperature for a material constituting the used water-insoluble matrix material.

[0034] The polishing pad of the first aspect of the invention may contain, in addition to the above-mentioned water-insoluble matrix material and water-soluble particle, an abrasive, an oxidizing agent, a hydroxide of an alkali metal, an acid, a pH adjusting agent, a surfactant, a scratching preventing agent and the like which have previously been contained in the slurry, at such an amount range that the light transmitting properties can be maintained. This makes possible to perform polishing by supplying only water during polishing.

[0035] In order to render better the affinity between the water-insoluble matrix material and the water-soluble particle, as well as the dispersity of the water-soluble particle contained in the water-insoluble matrix material, a compatibilizing agent may be incorporated. Examples of the compatibilizing agent include polymers, block copolymers and random copolymers, which are modified with acid anhydride group, carboxyl group, hydroxyl group, epoxy group, oxazoline group, amino group and the like, as well as a variety of nonionic surfactants, coupling agents and the like. These may be used alone or in combination of two or more.

[0036] Further, the polishing pad of the first aspect of the invention may contain a variety of additives such as a filler, a softening agent, an antioxidant, an ultraviolet absorbing agent, an antistatic agent, a lubricant, a plasticizer and the like, as option. Alternatively, reactive additives such as sulfur, peroxide and the like may be added to the polishing pad, which can be reacted and crosslinked.

[0037] Examples of the filler include materials for improving the rigidity such as calcium carbonate, magnesium carbonate, talc, clay and the like, and materials having the polishing effects such as silica, alumina, ceria, zirconia, titania, manganese dioxide, dimanganese trioxide, barium carbonate and the like. These may be used alone or in combination of two or more.

[0038] The polishing pad of the first aspect of the invention can be prepared by introducing a composition comprising the above-mentioned respective components into a mold having a prescribed shape.

[0039] The polishing pad of the first aspect of the invention can retain the slurry in pores and, further, can make wastages reside transiently. A planar shape of the polishing pad is not particularly limited but can be circle such as discs or polygon such as square (belt-like, roll-

light transmitting part comprises a water-insoluble matrix material and a water-soluble particle dispersed in the above-mentioned water-insoluble matrix material.

[0051] The "substrate for a polishing pad" according to the second aspect has the polishing performance by itself, and can retain the slurry on the surface thereof and, further, make wastages reside transiently. The transmitting properties of this substrate for a polishing pad may be present or absent. In addition, a planar shape thereof is not particularly limited but may be circle or polygon such as square. A size thereof is not particularly limited.

[0052] In order to retain the slurry and make wastages reside transiently during polishing, it is preferable that at least fine holes or grooves are formed on the surface of the above-mentioned substrate for a polishing pad. That is, fine holes and/or grooves may be pre-formed on the above-mentioned substrate for a polishing pad (for example, foamed body and the like), or pores and/or grooves may be formed on the substrate by dropping off during polishing. As the latter, a substrate for a polishing pad wherein a water-soluble material having a prescribed shape such as particulate form, linear form and the like dispersed in a water-insoluble matrix material may be used. By making a polishing pad provided with such the substrate for a polishing pad in contact with an aqueous medium during polishing, a water-soluble material is dissolved or dropped off, whereby, pores and/or grooves are formed on the surface of the substrate for a polishing pad.

[0053] A material constituting the above-mentioned substrate for a polishing pad is not particularly limited but a variety of materials can be used. In particular, it is preferable that an organic material is used because it is easily molded into a prescribed shape and nature and can give the suitable elasticity. As this organic material, foaming materials, and a variety of materials constituting a light transmitting part described later may be used. A material constituting the above-mentioned substrate for a polishing pad and a material constituting a light transmitting part may be the same or different.

[0054] A thickness of a substrate for a polishing pad of the second aspect of the invention may depend upon the use and is usually 0.5mm or more, preferably 1 to 3mm. The thickness of the substrate for a polishing pad may be constant overall or may be partially different.

[0055] The "through hole" penetrates the substrate for a polishing pad from the surface to the back and a light transmitting part is fitted in this through hole. The above-mentioned through hole may be provided at any position of the substrate for a polishing pad, for example, at a center, or at an end, or an end of the substrate for a polishing pad may be formed a vacancy part. A shape of the above-mentioned through hole is not particularly limited but, for example, a planar shape of an opening thereof may be circle, fan-shaped, polygon such as square and trapezoid, annulus and the like. In addition, a cross-sectional shape of the above-mentioned through hole may be, for example, T-letter shape, reverse T-letter shape, square or other shape (see Fig.8, 9, 10 and 11, In each figure, No.12 represents a substrate for a polishing pad and No.13 represents a through hole. Figures show that an upper side in each view is a polishing side.). Among them, a T-letter shape is particularly preferable.

[0056] A size of one of the through holes is not particularly limited. Usually, in the case where an opening is circle, it is preferable that a diameter is 20mm or more (usually, 2/3 of a radius of a polishing pad or less). In the case of an annular through hole, it is preferable that a width thereof is 20mm or more (usually, 2/3 of a radius of a polishing pad or less). In the case of square, vertical length of 30mm or more (usually, 2/3 of a radius of a polishing pad or less) and horizontal length of 10mm or more (usually, 2/3 of a radius of a polishing pad or less) are preferable. When each through hole becomes smaller than the above description, it may become difficult in some cases to assuredly transmit the light such as the endpoint detecting light. Besides, the number of through holes is not particularly limited.

[0057] The "light transmitting part" refers to a part that has the light transmitting properties for making detection of a polishing endpoint easy and is fitted in the above-mentioned through hole.

[0058] The above-mentioned light transmitting part comprises a water-insoluble matrix material and a water-soluble particle dispersed in this water-insoluble matrix material.

[0059] As a material for forming a water-insoluble matrix material constituting the above-mentioned light transmitting part, parts exemplified as a material for forming the water-insoluble matrix material with respect to the first aspect of the invention can be preferably used. Therefore, it is preferable that a water-insoluble matrix material constituting the above-mentioned light transmitting part is composed of at least a crosslinked polymer. It is also preferable that the crosslinked polymer is crosslinked 1,2-polybutadiene.

[0060] A water-soluble particle constituting the above-mentioned light transmitting part is not particularly limited. Considering the property which can be exerted at a magnitude of the light transmitting part, the water-soluble particle relating to the first aspect of the invention can be preferably used. That is, the same kind, shape and construction as those of the water-soluble particle relating to the first aspect of the invention may be used. In addition, as described above, an outer shell composed of epoxy resin, polyimide, polyamide, polysilicate or the like may be formed on the surface of the above-mentioned water-soluble particle.

[0061] The above-mentioned water-soluble particle has the function of compatiblizing an indentation hardness of a light transmitting part with that of other parts of a polishing pad, in addition to the function of forming a pore during polishing. In order to increase a pressure loaded during polishing, enhance a removal rate, and

same planar shape as that of the polishing pad. In the case the supporting layer has a part ensuring the transmitting properties by vacancy, the part may not be considered. In addition, this supporting layer may be one layer, or a laminate of two or more layers. Further, in the case where two or more supporting layers are laminated, respective layers may be composed of the same components, or may be composed of the different components.

[0074] A thickness of the above-mentioned supporting layer is not particularly limited but is usually 0.1 to 2 times as thick as a polishing pad. In addition, a hardness of the above-mentioned supporting layer is not particularly limited. However, by adopting a Shore D hardness of, preferably, 10 to 80, more preferably 20 to 50, even when a Shore D hardness of the polishing pad of the first aspect of the invention or that of the substrate for a polishing pad of the second aspect of the invention is as high as 60 to 90, a laminated body has the sufficient flexibility as a whole in polishing, and it can be appropriately adapted to the irregularity of the surface to be polished. A hardness of a supporting layer which is provided when the substrate for a polishing pad of the second aspect of the invention is used, is preferably smaller than that of the above-mentioned substrate for a polishing pad.

[0075] In the case where a supporting layer is provided in the polishing pad of the first and second aspects of the invention, it is preferable that at least a part used for detecting an endpoint of the supporting layer has the light transmitting properties. Therefore, a part of a supporting layer may be thinned and formed vacancy and, further, a part having the light transmitting properties may be provided on this vacancy part.

[0076] When a supporting layer having no light transmitting properties is used, methods of forming a vacancy at a part to be passed through the light and the like ensure the light transmitting properties of the laminated body for polishing.

[0077] A material constituting the above-mentioned supporting layer is not particularly limited but a variety of materials may be used. In particular, it is preferable that an organic material is used because it is easily molded into a prescribed shape and nature and also it can give the suitable elasticity. As this organic material, materials which are applied to a water-insoluble matrix material constituting the above-mentioned light transmitting part can be used, provided that, a material constituting the above-mentioned supporting layer and a material constituting a water-insoluble matrix material of the above-mentioned light transmitting part may be the same or different.

[0078] Since the polishing pads of the first and second aspects of the invention have the light transmitting properties, respectively, they can be used in a semiconductor wafer polishing apparatus equipped with an optical endpoint detector. In addition, a laminated body for polishing in which a supporting layer is laminated on the backside of the above-mentioned polishing pad can be also used in a semiconductor wafer polishing apparatus equipped with an optical endpoint detector, by provision of a part through which the light transmits by forming a vacancy part in the above-mentioned supporting layer. This optical endpoint detector is an apparatus which can observe the polishing situations with the light reflected on the surface of a material to be polished, and can detect a polishing endpoint. When a polishing pad or a laminated body for polishing has a disc-like shape, by provision of light transmitting parts at a center of this disc and concentrically on the disc in the ring-form, it becomes possible to polish while usually observing a polishing point. When this optical endpoint detector is used, polishing can be assuredly terminated at an optimal polishing endpoint without excess polishing, which is effective.

[0079] The method for polishing of a semiconductor wafer of the present invention is a method employing the above-mentioned polishing pad or laminated body for polishing and is characterized in comprising a process of performing detection of a polishing endpoint using an optical endpoint detector.

[0080] The "optical endpoint detector" can be the same as described above. In the method for polishing of a semiconductor wafer of the invention, for example, a polishing apparatus as shown in Fig.24 may be used. That is, the polishing apparatus is an apparatus provided with a polishing pad 1, a rotatable surface plate 2 being capable of fixing the polishing pad 1 on, a pressure head 3 being capable of rotating and moving in vertical and horizontal directions, a slurry supplying part 5 which can drop the slurry on the surface plate at a constant amount per unit time, and an optical endpoint detector 6 mounted under the surface plate.

[0081] In this polishing apparatus, a polishing pad (or a laminated body for polishing) 1 of the present invention is fixed on the surface plate. On the other hand, a semiconductor wafer 4 is fixed on a lower end side of a pressure head 3, and this semiconductor wafer 4 is abutted against the polishing pad 1 while pushing with a prescribed pressure. Then, while a prescribed amount of the slurry is added dropwise on the surface plate from the slurry supplying part 5, the surface plate 2 and the pressure head 3 are rotated to slide the semiconductor wafer 4 and the polishing pad 1, to perform polishing.

[0082] Upon this polishing, the endpoint detecting light R_1 having a prescribed wavelength or a wavelength region is irradiated to the surface to be polished of the semiconductor wafer through the polishing pad of the first aspect of the invention or the light transmitting part according to the second aspect of the invention, from a lower side of the surface plate 2(the endpoint detecting light can transmit the surface plate when the surface plate itself has the light transmitting properties or a vacancy part is formed at a part of surface plate), from an optical endpoint detector 6. Then, the reflected light R_2 which is this endpoint detective light reflected on the sur-

Example 1

[1] Preparation of a polishing pad

[0088] 80% by volume of 1,2-polybutadiene (trade name "JSR RB830" manufactured by JSR Corp.) which becomes a water-insoluble matrix material by crosslinking later, and 20% by volume of β-cyclodextrin (trade name "Dexypearl β-100" manufactured by Yokohamakokusaibiokenkyusho Co. Ltd.) were kneaded with a kneader heated to 120°C. Thereafter, 0.2 part by mass of dicumyl peroxide (trade name "Percumyl D" manufactured by NOF Corp.) was added to a total of 100 parts by mass of total of 1,2-polybutadiene and β-cyclodextrin, which was further kneaded, reacted to crosslink at 170°C for 20 minutes in a press mold, and molded to obtain a disc-like polishing pad having a diameter of 60cm and a thickness of 2mm.

[2] Measurement of the transmittance

[0089] The transmittance of the resulting polishing pad at a wavelength ranges between 400 and 800nm was measured at five different points on the polishing pad using a UV absorbance measuring device (Model "U-2010" manufactured by Hitachi Ltd.), and an average was calculated. As a result, an average integrated transmittance of five times was 7%. In addition, the transmittance at 633nm (wavelength of a general He-Ne laser) was 6.5%.

[3] Measurement of the polishing performance

[0090] The polishing pad obtained above was mounted on a surface plate of a polishing apparatus, and a hot-oxidized layer wafer was polished under the conditions of a surface plate rotation number of 50rpm and a slurry flow of 100cc/min. As a result, a removal rate was 980Å/min.

Example 2

[0091] Using a polishing pad composed of commercially available polyurethane foam having no light transmitting properties (trade name "IC1000" manufactured by Rodel Nitta), polishing was performed under the same conditions as those of Example 1, and a removal rate was 950Å/min. A circular through hole having a diameter of 20mm was provided on this polishing pad, and a light transmitting part having the same constituent as that of the polishing pad in the above-mentioned Example 1 was fitted therein. Polishing was performed under the same conditions as those of Example 1 using this new polishing pad, and a removal rate was 950Å/min.

[0092] As a result, even when, a light transmitting part molded in a prescribed size is fitted in a through hole provided on a part of a polishing pad composed of polyurethane foam having no light transmitting properties to obtain a polishing pad, which is used to perform polishing, it can be seen that the polishing performance of a polishing pad composed of polyurethane foam having no light transmitting properties is not lowered.

[0093] An objective of the present invention is to provide a polishing pad for a semiconductor wafer and a laminated body for polishing of a semiconductor wafer equipped with the same which can perform optical endpoint detection without lowering the polishing performance as well as methods for polishing of a semiconductor wafer using them. The polishing pad of the invention comprises a water-insoluble matrix material such as crosslinked 1,2-polybutadiene, and a water-soluble particle such as β-cyclodextrin dispersed in this water-insoluble matrix material, and has a light transmitting properties so that a polishing endpoint can be detected with a light.

Claims

1. A polishing pad for a semiconductor wafer, which comprises a water-insoluble matrix material and a water-soluble particle dispersed in said water-insoluble matrix material, and has light transmitting properties.

2. The polishing pad for a semiconductor wafer according to Claim 1, wherein said pad has a thin part, and an endpoint detecting light is transmitted through said thin part.

3. The polishing pad for a semiconductor wafer according to Claim 1 or 2, wherein a light transmittance at a wavelength between 400 and 800nm is 0.1% or more, or an integrated transmittance in a wavelength range between 400 and 800nm is 0.1% or more, when a thickness is 2mm.

4. A polishing pad for a semiconductor, which comprises a substrate for a polishing pad provided with a through hole penetrating from surface to back, and a light transmitting part fitted in said through hole, wherein said light transmitting part comprises a water-insoluble matrix material and a water-soluble particle dispersed in said water-insoluble matrix material.

5. The polishing pad for a semiconductor according to Claim 4, wherein a light transmittance of said light transmitting part at a wavelength 400 and 800nm is 0.1% or more, or an integrated transmittance of said light transmitting part in a wavelength range between 400 and 800nm is 0.1% or more, when a thickness is 2mm.

6. The polishing pad for a semiconductor according to any one of Claims 1 to 5, wherein at least a part of

Fig. 1

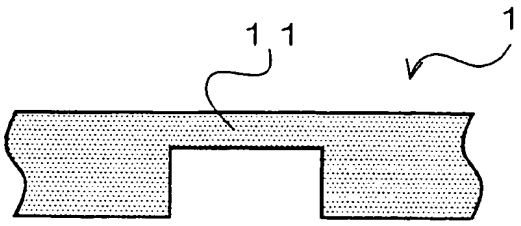


Fig. 2

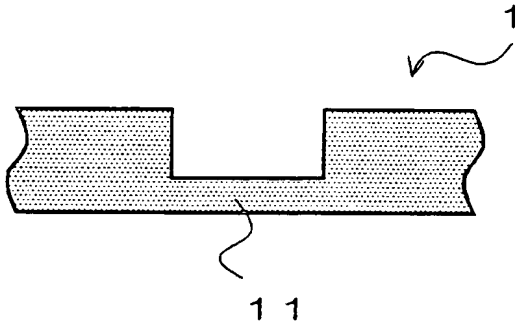


Fig. 3

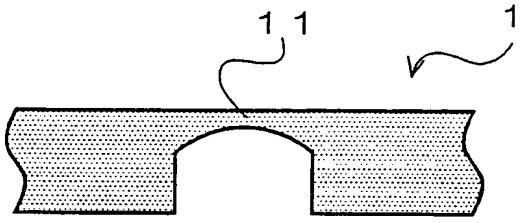


Fig. 4

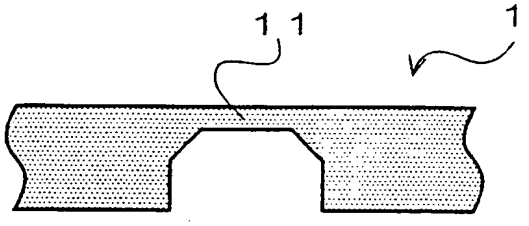


Fig. 7

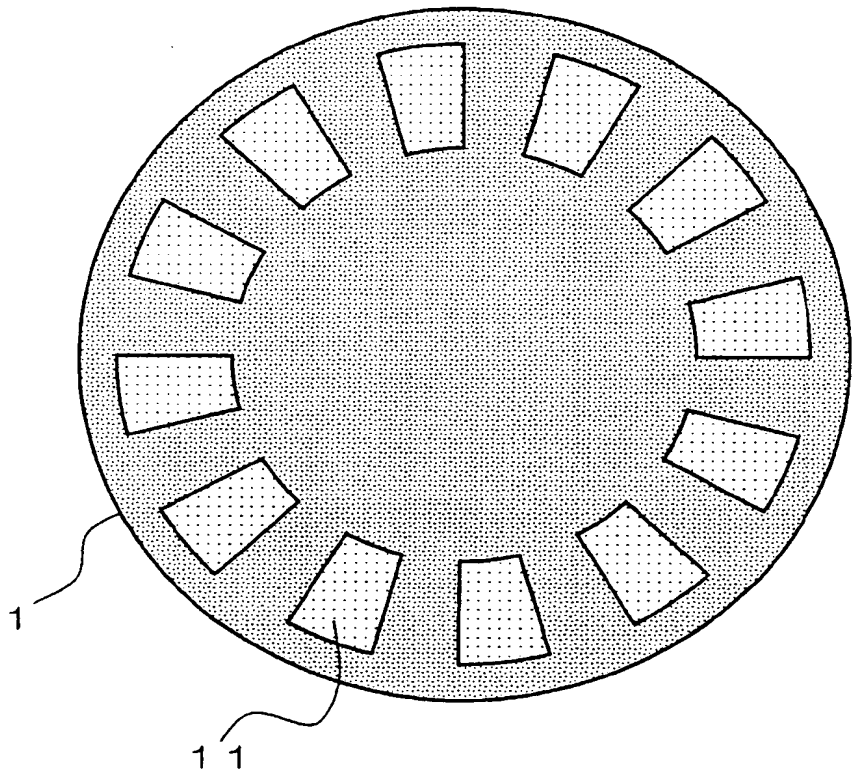


Fig. 12

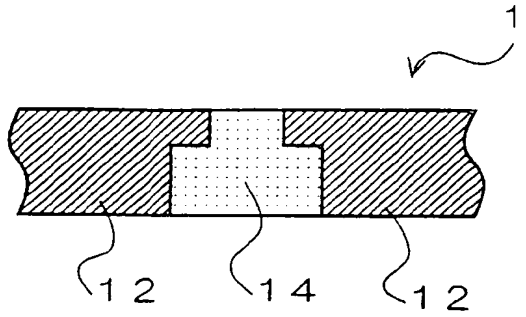


Fig. 13

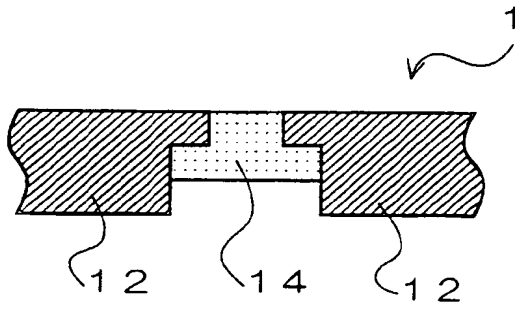


Fig. 14

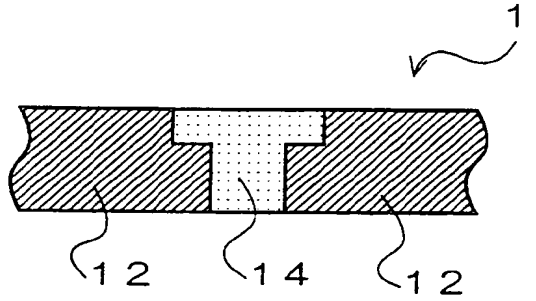


Fig. 15

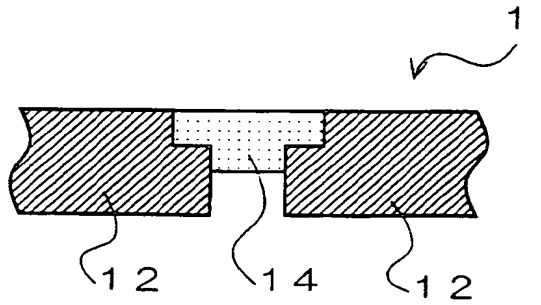


Fig. 20

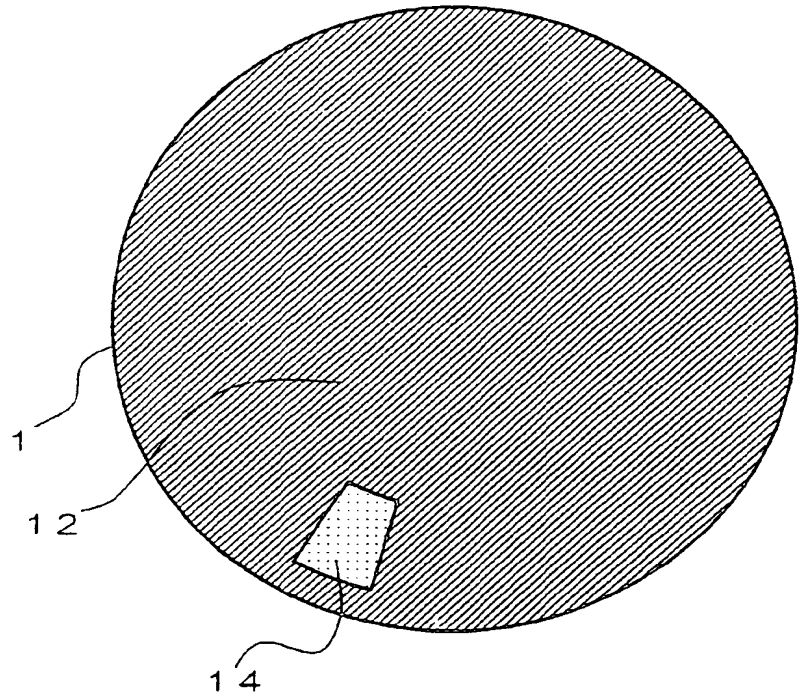
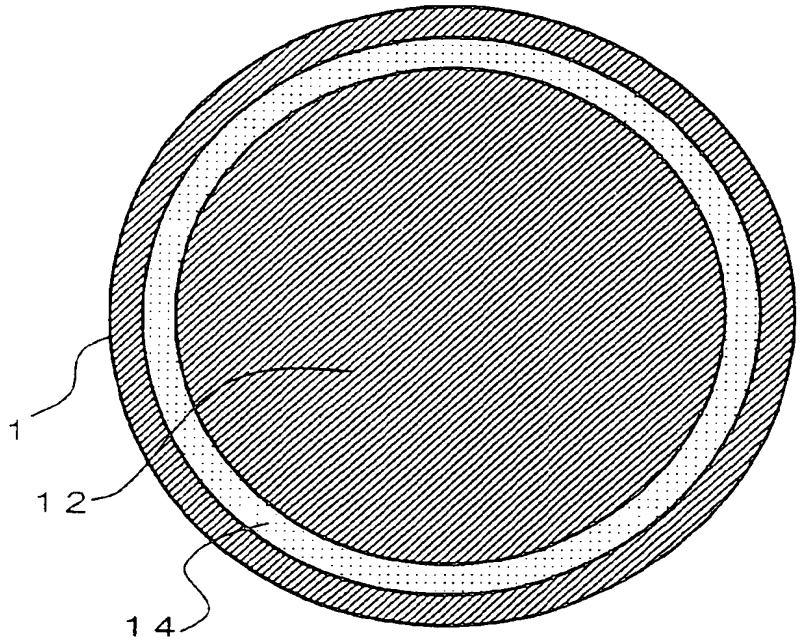


Fig. 21



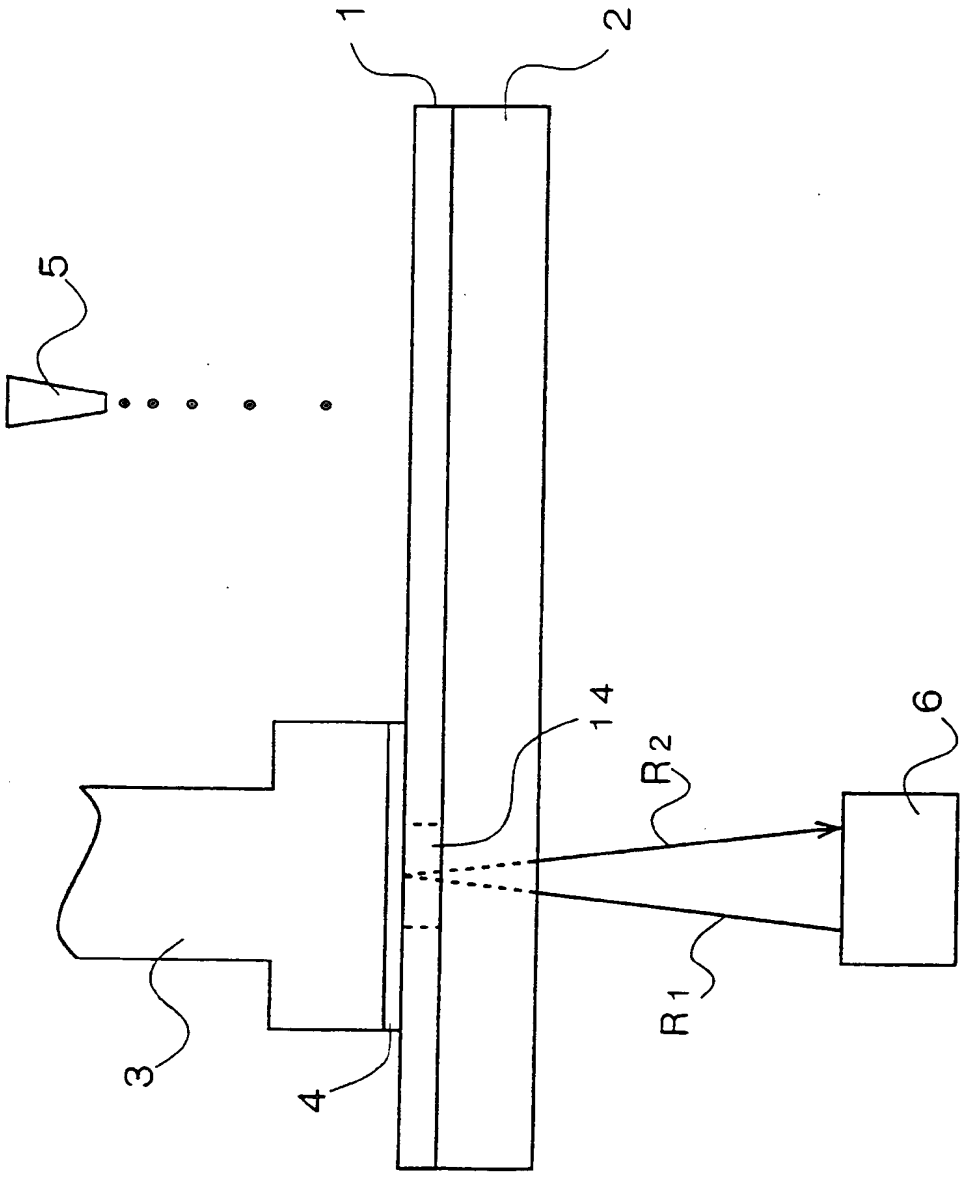


Fig. 24

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 02 00 9155

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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